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APPLICATION OF VIDEO SURVEILLANCE AS A SERVICE (VSaaS) IN THE AREA OF TRANSPORTATION

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***Abstract**:Implementing a system for video surveillance allows monitoring and management of traffic in order to increase the security and safety of all road users. This system provides real-time information on traffic flow, congestion and if there are any potential security risks in different parts of the road. Modern systems have the ability to control traffic lights and to redirect the driver to alternative routes to optimize the flow of traffic. Taking into account the difficulty of such operations large computer resources are necessary for processing data in real time what today can be achieved only through the use of cloud services and supporting technologies. This paper provides an overview of the existing ICT solutions for video surveillance of traffic using cloud technologies, as well as proposals for their implementation.*

Keywords:Video surveillance as a service (VSaaS), traffic safety, cloud coumputing (CC), information technology (IT).

1. Introduction

As computing power exponentially increases every year, the implementation of computer video slowly becomes a viable solution to many of the current problems that the car industry faces. Intelligent Transport Systems (ITS) [35] use advanced computing, sensory [34], and telecommunication technologies in traffic systems. In the field of traffic detection, public agencies and consulting firms have been relying on magnetic strips installed for the past just under its surface for years [32]. Such a system, however, is expensive to look at installation costs, has limited coverage, and can only satisfy a limited number of functions such as counting vehicles or determining speed. In order to overcome the limitations of such a system, modern cloud video technology has been introduced into the co-administrative tool in support of decision-making in traffic control. Video surveillance of traffic is one of the most promising areas for the improvement and development of modern video technology. Although significant progress has been made in this field, there remain a number of problems such as vehicle occlusion and false detection. In addition to all available technologies for monitoring and managing traffic systems, the greatest progress is needed in the area of system adaptability to the dynamic nature of traffic [33]. Clouds services appear on the scene as a revolution in the control of large and complex video surveillance systems, which will be described in more detail in this paper. The available literature deals with these disadvantages and support technologies, and some of the most important research include: synthesis of data from video surveillance applications [3,10], elimination of damaged frames from images using histogram [8], improvement of service quality in mobile clutches for video surveillance [21], the collection of traffic data using Bluetooth technology [21], removal of vehicle shadows to prevent false detection [22,42], integration of radar and cloud technology in air traffic monitoring [26], assessment of the condition on clustering analysis [30] , software calibration of the video surveillance system [43].

2. Cloud service models

Cloud computing (CC) or commonly called "self-cloud" represents the delivery of computer resources on demand, that is, everything from software, hardware and data processing is delivered to users by model of renting services over the Internet. The hardware background of the cloud is a huge computer center distributed to all over the world by standard Internet protocols that pool individual resources in order to distribute and speed up task processing. The main purpose and also the benefits of cloud technology are "elastic resources" that allow the user to use as many resources as he needs for a specific purpose. An example of this may be the case that it is necessary to compress 12 hours of video material in a 4k resolution that was collected during one trip. An average home computer would need several days of continuous work for this job which would prevent users from performing other tasks on the same computer due to too much hardware load. By using cloud resources, the same task would be done in an hour, which saves time and money to the user, and the home computer can be used for other purposes.

Modern cloud video surveillance consists of three basic service models: 1. Software as a service (SaaS) is cloud-based applications running on remote computers and delivered to the user through the Web browser. The benefits of SaaS include the current availability of the latest software, the availability of software from any computer through one Internet account, exceptional software stability, cloud security, and dynamic scaling of resources relative to needs. 2. Platform as a Service (PaaS) is a middle application layer, such as an operating system or development environment that, in its turn, supports the entire lifecycle of building and delivering Web-based applications - without the cost and complexity of purchasing and

managing background hardware , software, settings and hosting. The benefits of the PaaS service model include faster development and delivery of applications, reduced complexity with the middle application layer through predefined and configured settings.

3. Infrastructure as a Service

- **(IaaS)** represents a hardware setting of computer resources such as a server, a network, a warehouse porter that the user can rent for their own needs. This service model is often called i-metal. Bare metal‖ which indicates the lack of supporting software other than the one necessary for connecting hardware components. The advantages of IaaS include reduced operating costs because there is no need to purchase expensive hardware and its maintenance, infrastructure is piled as needed, and allows the use of ready-made innovative solutions on request. Figure 1 graphically depicts the architecture listed three service models in the clod.

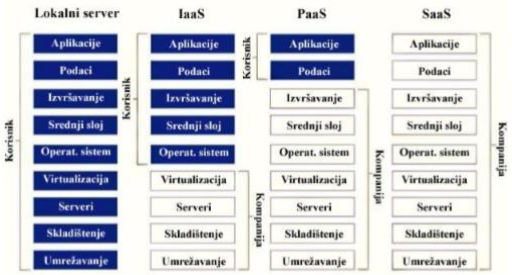

Figure 1. Characteristics of IaaS, PaaS and SaaS services

Cloud technologies can be divided into three basic types: 1. Public cloud (cloud) is a type owned by a company that is responsible for setting up and operating the cloud and exclusively leases its resources to users. In a public cloud, users share resources for which they pay for a specific period of time. In practice, this is accomplished using cloud resource units, so-called. -cloudlets‖ where one cloudlet has 400 MHz processors and 128 MB of RAM. Key aspects of the public cloud include ready-made software solutions, flexible and scalable IaaS for storage and data processing, as well as a strong platform environment for the development and delivery of applications. 2. Private cloud (Cloud) is a type of cloud that is intended for use within one organization, that is, all resources are put on the use of one user. It can be developed internally or by a third party and in most cases it is maintained internally through IT staff, although there are cases of third party support. Benefits of private cloud are reflected in increased resource control, specially designed interface, advanced security, because the location of data is known, high automation of the process tailored to the needs of the organization. 3. Hybrid cloud (Hybrid cloud) is an integrated use of the previous two types that implies the strategic integration and use of public cloud services in a private setting. In practice, a private cloud can not function in isolation from the rest of the organizational IT network and resources and public clowns. Most organizations resort to a solution where work processes are distributed across data centers, private and public cloud, and thus create a hybrid cloud [45]. Key aspects of the hybrid cloud allow the organization to retain critical applications and data within a traditional network or private cloud while using the flexibility of a scalable infrastructure to expand the capacity and processing speed. This type also allows portability of data and applications, if needed, with high transfer security.

3. Video surveillance as a service (VSaaS)

Video Surveillance as a Service (VSaaS) is intended to provide an omnipresent and on-demand access to the network of shared multimedia data. The service enables quick, easy download, processing and sending of materials without the need for interaction with the service provider and other third parties. The video surveillance process in the cloud is quite simple and reliable for the end user [47]: the set camera captures and transmits audio / video material, sends it using an Internet connection to a cloud

where Video Management Software (VMS) delivers, On request, the material to the end user. All architecture can be: public, private and hybrid. Public architecture implies that a user rents an almost solution from a service provider only by connecting his or her cameras to a personal account of a service. The entire process of processing and storage is done on the provider's side, which is in practice the most used way of using this service [28]. Private architecture is applied only in cases where there are staff capable of handling such a complex system, which is a much more expensive option.

Figure 2 gives an example of the architecture of the VSaaS workspace that was developed by the author [23]. The basic mechanism of the given work frame has the following characteristics: Video content is obtained from video cameras from different sources of application using the -push-pull mechanism; The main component is a post-subscribe broker (subscribe broker) who redirects claud data to the user based on his subscription; All processes are regulated by a cloud manager whose purpose is to manage interactions between users and component directories; The directory of multimedia services contains all the functionality of video services and are designed according to the service-oriented architecture (SOA) of the architectural form; The resource allocation manager has the purpose to manage and allocate various resources of the Virtual Machine (VM) monitoring system and related services; Monitoring and accounting component monitors the use of resources and provides insight into usage statistics and service charge collection.

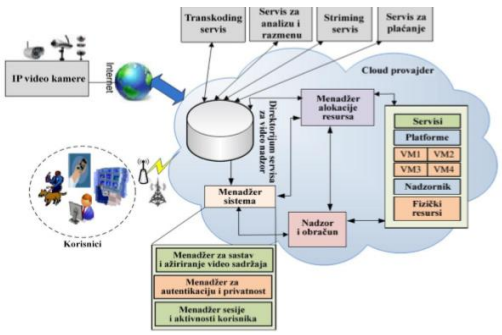

Figure 2. Example of the VSaaS of the working frame [23]

There are several versions of VSaaS services, such as [11-12, 15-17]: Intelligent Video Surveillance-as-a-Service (IVSaaS), Managed Video Surveillance-as-a-Service - MVSaaS), Cloud Video Surveillance (CVS) and Online Video Surveillance as a Service (OVSaaS).

Figure 3 shows the development trend of video surveillance technology since its inception in the early 1950s [11]. At that time, there were no ways of long-term recording of images, but only live monitoring in dedicated rooms by engaging a large number of staff. It was only in the mid-1960s that I discovered video tapes that it became possible to combine existing CCTV systems to store and delete video material. Video surveillance technology has been significantly improved by the introduction of a Digital Video Recorder (DVR). Although the first proposals for the development of this technology date back to the 1980s, the first commercial application for video surveillance began in the late 1990s. DVR technology has provided significantly more storage space as well as faster search of recorded material, as well as support for connection to a computer.

Internet Protocol (IP) video surveillance systems appeared shortly after the discovery of the IP camera in the late 1990s, and by 2005 most of the surveillance system was using this technology. VSaaS technology appeared in the early 2010s and is now the most advanced video surveillance solution. The future will be without discussion intelligent cloud systems, through neural networks and machine learning [29], which are currently in the research and development phase.

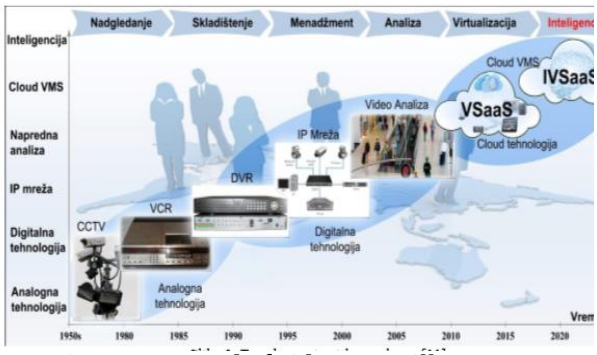

Figure 3. Trend of video surveillance development [11]

Compared to traditional systems, cloud video surveillance has significantly less security vulnerabilities. There is no need for a specific software, firewall and open ports [48-50]. There is also no possibility that the stored data be threatened by theft, user error, power failure, etc. Increased data security is the result of a distributed architecture, data is replicated at several times at several physical locations. Control is available from any smart device at any time, which provides even greater security. VsaaS service providers have dedicated security teams that detect vulnerabilities and apply software updates via cloud to devices at the control site.

4. Application of cloud video surveillance in the assembly

Video surveillance of traffic is an important function in maintaining safety and rapid response to indications. Cloud video surveillance allows real-time tracking of real-time road conditions for a large number of cameras with a reduced number of operators in the control center. Through advanced algorithms, modern systems can simultaneously track thousands of cameras and provide notifications only if abnormal behavior is detected from the given parameters. So, if there is slowed down traffic on a particular route, the system can adjust the light signaling to disassemble that section. The same images can also be distributed to the public over the Internet in order for drivers to decide independently on the road to move. Using a computer video, it is possible to automatically monitor the number of vehicles, their speed, type of vehicle, incidents and alert to the competent services [18]. All of these parameters significantly contribute to engineers in further design or alteration of existing roads for the purpose of more efficient traffic management. Vehicle type information helps in predicting road maintenance by analyzing the number of heavy vehicles that are most damaging to kolovoz. The system is also capable of recognizing the movement of the opposite tape, the crossing of the full line, the crossing of the pedestrians through the zebra or outside, as well as extending the duration of the red light if there are still people on the pedestrian crossing. Figure 4 illustrates the applicability of the cloud system for the needs of video surveillance for applications throughout the city system including the traffic systems.

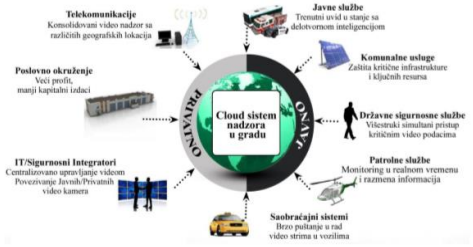

Figure 4. An integrated video surveillance environment in the city

A typical cloud solution for video surveillance includes [31]: • Project design, management and implementation, • Consolidation and centralization of existing cameras, • Conversion of existing analogue cameras to digital, • Design and integration of wall systems for display, • Design and implementation of centers for monitoring, • Choice of use between private or rented cloud, • Possibility to carry out public-private partnerships (PPP), • Building mobile data centers in rural areas, • Fast and cost-effective implementation of data centers, • Quick release of video streams in vehicles, • Fast and economical implementation of wireless networks, etc.

The operating frame of the cloud video surveillance system that can be used in

traffic is shown in Figure 5. Specific components are listed as well as their interaction. The given framework provides a scalable and automated solution for obtaining, storing and analyzing video strips with minimal latencies and user intervention. The given work frame efficiently performs the above functions using Graphic Computing Unit (GPU) in the cloud setting, which significantly reduces the processing time as opposed to the classic processors. The software background of the framework enables the automation of the process of identifying and searching objects or significant events [14].

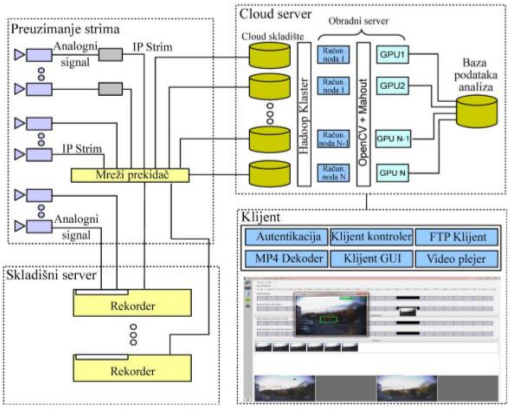

Figure 5. The operating framework of the traffic monitoring software system using cloud technology [4]

Automatic video analysis is performed with minimal interaction of the operator by defining the analysis requirements in the client control component. The request for analysis is sent to the cloud data center where, based on the given parameters, the required video is recorded from the cloud storage. The video is then analyzed and the results are sent to the database analysis. Then the operator can access this database and get a complete analysis report [13].

Workspace components are designed with a modular approach and are divided into client and server components. The server component is executed as a service on cloud nodes and performs the main task of analyzing video streams. The client component supports a multi-user environment and runs on local computers. Data flow and controls are divided into three phases in this working framework: 1. downloading video streams, 2. video stream analysis and 3. storing results and notifying operators. The layout of the components is as follows:

- Video streaming component is located at the source or location and is connected to the storage component on the server through the LAN connection; Cloud data storage and processing servers are located in the cloud center and / or service providers;
- Client component or user software is located at the user's kernel on the computer.

Table 1 gives the benefits of using cloud video surveillance in relation to the traditional system, based on which it can be clearly concluded that the use of cloud technology is of great advantage.

Cloud video nadzor	Tradicionalni sistem
Otvoreni sistem baziran na Internet protokolu	Zatvorena arhitektura u privatnom vlasništvu
Centralizovano upravljanje videom i pristup kroz jedno prijavljivanje	Zahteva prijavljivanje na individualne DVR uređaje
Udaljeno snimanje i skladištenje videa	Lokalni DVR uređaj ili drugi uređaji za snimanje
Višestruki simultani pristup bez degradacije kvaliteta videa	Video kvalitet se smanjuje porastom korisnika
Integracija postojećih CCTV i IP kamera	Uglavnom koristi specifične uređaje
Redundantnost podataka i brži pristup sa centralnog clouda	Odvojeni i nezavisni uređaji za skladištenje
Integrisani grafički korisnički interfejs (GUI) i korisnička kontrolna tabla	Individualni alati za svaku različitu sistemsku funkciju
Automatsko prepoznavanje uređaja i konfiguracija računarskih mreža	Zahteva konfiguraciju uređaja i softversku nadogradnju na terenu
Arhitektura prilagodljivog sistema	Samo funkcije definisane od strane proizvođača

Table 1. Benefits of using VSaaS services

Figure 6 shows the work frame of the software in charge of analyzing video streams. The analysis process begins by downloading a short clip of video streams with set-up cameras and a calibration of a scene that implies setting the stops for the capturing zones, entering the vehicle on the scene, counting and assigning attributes [6]. The input zone is determined by the bandwidth and length of the observed scene and represents the maximum region where the detection is performed [44]. The video is separated into image sequences, which are then individually added to the background removal filter, and then the Haar-Cascade detection algorithm for determining existing vehicles in the image.

For each detected vehicle, the tracking algorithm records its movement along the x-y plane of the road for all upcoming frames as long as the vehicle is in the input zone. With motion tracking, the dimensions of the vehicles are simultaneously

determined to determine the type, the transformation of the coordinates (transformation from the 2D image to the 2D plane of the path), the acceleration and the speed. At the same time, the movement of each vehicle is sent iteratively to an algorithm for identifying false detection or occlusion in order to avoid miscalculation and entry into the analysis database.

Occlusion identification is a higher priority and begins before identifying false detection. As soon as the vehicle is recognized as an obscure object, the software excludes it from further analysis and switches to the next object. For this reason it is very important that the camera is located in a place where there are no artificial barriers like columns and signs. The identification of false detection takes into account the speed of the object's movement in relation to the set parameters for that region and automatically excludes objects moving at a speed that emanates from the setpoint limits. This prevents the detection of humans and animals. Finally, as the vehicle enters the counting zone and is a successfully detected counter, it increases the value and additional attributes such as speed, type of vehicle, and tape in which they move into the base. Repeatedly described procedures for complete monitoring of monitoring are aggregated reports that can then be searched and downloaded by the operator.

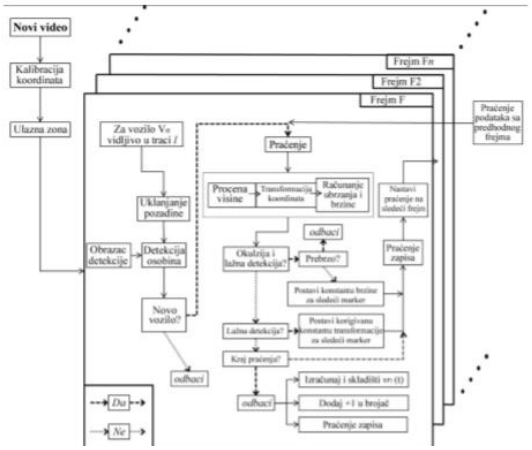

Figure 6. Software video analysis framework [6]

Figure 7 shows an example of a software that measures various traffic parameters such as the number of vehicles moving with a certain band (1), a class of vehicles such as motorcycles, passenger and freight vehicles (2) and vehicle speed (3) at the moment of entering the observed region (4). On the right side, the software records static images of the vehicle with the corresponding parameters (5). The software also estimates the number of vehicles that change tape that can be used to predict traffic density. The system was developed in Microsoft Visual C ++ 2010 using the OpenCV library as a master project [41]. OpenCV (Open Source Computer Vision Library) is a software library for image analysis and machine learning. This library was developed by Intel in 2008 and has the API for C, C ++, Python, Java and MATLAB programming languages. The library has more than 2500 optimized algorithms for face, object recognition, classification, tracking, counting, etc. Such a video surveillance system is also called multi-agent [1] for the purpose of using multiple separate components for the purpose of joint operation or, processing. Some of the developed platforms and traffic control systems include ZigBee [2], TRICam [5], and ADAS (Airborne Data Acquisition System) [7]. For the purpose of controlling areas with low availability of the Internet, wireless systems have been developed that connect each other to a place with an Internet access [19-20]. Vehicle trajectory detection as well as additional attributes are subject to more research and developed solutions [24,25,27,28,36,46]. Specific applications such as prediction of pollution of locusted traffic loci in traffic using neural networks have been developed [40], camera location optimization [38], real time control of large scenes [37], automation of control devices for the purpose of optimizing large city systems [39].

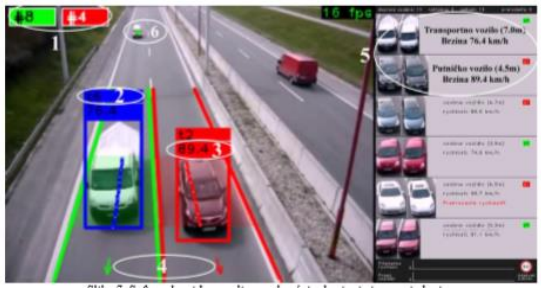

Figure 7. Software video analysis of traffic, counting and measuring speed

Figure 8 provides examples of software analysis of various traffic cases, and a) the availability of parking spaces, where the software automatically keeps track of occupancy, retention time and billing for collection. By using a mobile application, the driver is able to get an insight into the availability of parking spaces in advance, make a reservation and pay for parking. b) simultaneously tracking the speed of multiple vehicles, with automatic recording of offenses and alerting the operator; c) monitoring the observance of the traffic lights, where we can see how the car performs a violation by switching to the red light. This application has proved to be extremely useful as evidence and results in increased security and faster resolution of disputes. D) Pedestrian crossing monitoring is among the latest video surveillance functions due to the complexity of the implementation. It has proved successful in real situations where the system can extend the duration of the traffic light if a person is at the crossing passage or detects the improper movement of pedestrians or vehicles.

4. Conclusion

The use of video surveillance is necessary in traffic systems, especially if modern information technology (IT) is supported. It provides protection for people, road infrastructure and minimizes accidental incidents. Previously only richer countries and cities could afford IP-based video surveillance, while this technology is now available to a wider circle for ease of installation, significantly reduced implementation and maintenance costs. Currently, about 10 percent of all video surveillance systems are connected to the worldwide network through cloud technologies with high growth rates. One of the key benefits of using cloud based video surveillance systems is their ability to protect the integrity and availability of recorded media.

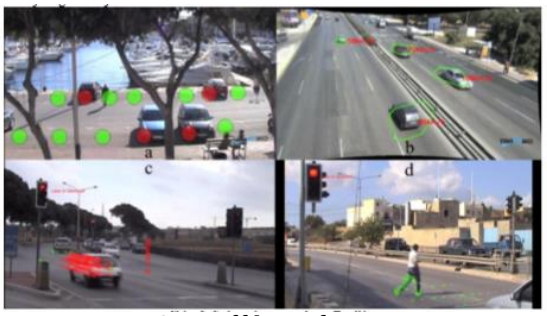

Figure 8. Traffiko software system

Cloud services integrate many features that prevent data loss, backup of critical data, and fast recovery from unexpected cancellations. The network management system can monitor all networked devices, automatically generate alerts or notifications, and intelligently manage traffic signals and electric ramps at the crossings. Regardless of the current achievements in this field, further development is needed in order to create safer roads for both passengers and the general public.

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